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Experimental Investigation on the Performance and Analysis of Cooling Tower with Different Fan Material and Blade Angle

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Abstract **- Cooling towers are one of the crucial biggest warmth and mass transfer contraptions used to switch approach waste heat to the atmosphere. Cooling towers make use of evaporation whereby one of the most water is evaporated into a relocating air movement and due to this fact discharged into the atmosphere. As a result, the rest of the water is cooled down tremendously. The system parameters similar to inlet air cost, water float expense and fills porosity have more impact on thermal performance of cooling tower. The temperature of outlet water is maintained nearest to inlet air wet bulb temperature to receive the excellent thermal performance of cooling tower. In this present be trained, the explanation affecting the performance like environmental stipulations, cooling water quality and then the fan angle were studied on induced draft cooling tower of thermal power stations. The main aim of the paper is to analyze the efficiency of the cooling tower by changing the cooling tower fan material and its angle. In this paper, the analysis has done by using CFD software.**

Keywords – Power plant, Cooling tower, Induced draft, Wet bulb temperature, Cooling tower fan, Angle, Environmental stipulations, Performance and Analysis

List of Symbols

T	Temperature	^oC
P	Pressure	N/m^2
WBT	Wet bulb temperature	^oC
DBT	Dry bulb temperature	^oC
Q	Heat transfer	KJ/hr
V	Velocity	m/s
ρ	Density	kg/m^3
C_{PW}	Specific heat of water	KJ/kgK
ɳ	Efficiency	%

I. INTRODUCTION

Cooling towers are water conservation devices. Waste heat is rejected to the atmosphere by evaporative and sensible heat transfer this allows the water to be recycled to the chiller condenser to repeat the cycle.

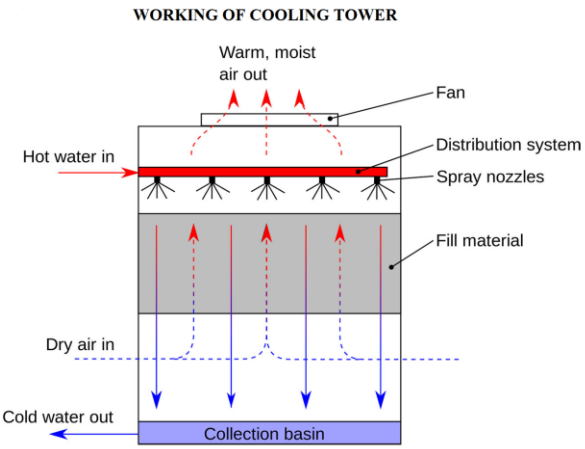

Fig .1 Working of Cooling Tower

Cooling towers may just either use the evaporation of water to remove procedure warmth and cool the working fluid to close the wet bulb air temperature or, within the case of closed circuit dry cooling towers, count solely on air to cool the working fluid to near the dry bulb air temperature.

II. LITERATURE REVIEW

[1] R.Ramkumar A.Ragupathy has examined an exploratory examination of the warm execution of constrained draft counter stream wet cooling tower with extended wire work write pressing. The pressing utilized as a part of this work is wire work with vertical [VOWMP] and level [HOWMP] introductions. The pressing is 1.25 m stature and having a crisscross shape. From the analyses it is presumed that the vertical introduction of the pressing upgrade the execution of the cooling tower

[2] XiaoniQi, Yongqi Liu, Zhenyan Liu has portrayed about an unmistakable scientific model of vitality and exergy for a shower cooling tower (SCT). The model is utilized to foresee the variety in temperature and exergy along the pinnacle length. The legitimacy of the model for anticipating varieties in gas and fluid attributes along the pinnacle length was analyzed against some working information estimated in a cooling tower organization. The outcomes demonstrate that the exergy of water diminishes as tower stature increments. The appropriation of the exergy misfortune is high at the base and slowly diminishes climbing to the highest point of the pinnacle. In addition, 1.50 m/s air speed brings about less exergy pulverization. With a decline in the span of the water beads, the liquids conveying vitality have more open doors for mass and vitality exchanges.

[3] Pushpa B. S, VasantVaze, P. T. Nimbalkar has utilized an evaporative cooling tower is a warmth exchanger where change of warmth happens from flowing water to the climate. The warm water from the condenser is taken as a gulf water to the cooling tower and it is permitted to course through the spouts. As it tumbles down crosswise over astounds or louvers, the water is broken into little beads. All the while air is attracted through the air bay louvers gave at the base of the pinnacle and after that this air ventures upward through the pinnacle the other way of water stream. In this procedure a little bit of water gets vanished which expels the warmth from the rest of the dilute making it cool. This water is gathered in a bowl and is reused in the cooling water framework process. On account of dissipation, some amount of water is lost and in this way to make up the misfortune, the crisp water is continually added to the cooling water bowl. In a Natural Draft Cooling Tower, warm water is cooled by dissipation process. Here, water gets cooled when a limit layer is shaped between immersed water and soaked air. In the event that the mass stream rate is perfect, at that point the execution of cooling tower and additionally the power plant will be progressed. In this investigation, it is demonstrated that by limiting the extent of water bead, the execution of Natural Draft Cooling Tower can be upgraded. Investigation of Sensitivity Analysis is done which demonstrates the reliance of parameters like air temperature, water temperature, relative dampness and rate of warmth misfortune. Further, effectiveness is likewise checked by utilizing power age information and result found was great.

[4] Ronak Shah, Trupti Rathod has depicted a point by point procedure for warm plan of cooling tower. The specialized information is taken for Mechanical draft cooling tower The plan of cooling tower is firmly identified with tower Characteristic and diverse sorts of misfortunes created in cooling tower. Despite the fact that misfortunes are created in the cooling tower, the cooling is accomplished because of warmth exchange amongst air and water. In perfect condition, the warmth misfortune by water must be equivalent to warm pick up via air. Be that as it may, in genuine practice it isn't conceivable in light of some sort of misfortunes. Cooling tower execution increments with increment in wind stream rate and trademark diminishes with increment in water to air mass proportion.

[5] Lu, W. Cai has portrayed about a widespread designing model, which can be utilized to plan both counter stream and cross stream cooling towers. By utilizing major laws of mass and vitality adjust, the adequacy of warmth trade is approximated by a moment arrange polynomial condition. Gauss - Newton and Liebenberg-Marquardt strategies are then used to decide the coefficients from makes information. Contrasted and the current models, the new model has two primary preferences: (1) As the designing model is gotten from building point of view, it includes less info factors and has better depiction of the cooling tower activity; (2) There is no iterative calculation required, this component is essential for online improvement of cooling tower execution. Despite the fact that the model is basic, the outcomes are extremely precise. Application cases are given to contrast the proposed display and generally utilized models.

[6] B Bhavani Sai, I Swathi, K S L Prasanna, K Srinivasa Rao has portrayed a nitty gritty philosophy of an Induced draft cooling tower of counter stream compose in which its productivity, viability, attributes are figured. The specialized information has been

taken from a mechanical draft cooling tower. Cooling towers are warm evacuation gadgets used to exchange process squander warmth to the air. Cooling towers make utilization of dissipation whereby a portion of the water is vanished into a moving air stream and accordingly released into the air. Accordingly, the rest of the dilute is cooled altogether

III. MAJOR COMPONENTS OF COOLING TOWER

It include,

- ✓ Cold water basin
- ✓ Fills
- ✓ Drift eliminator
- ✓ Cooling tower fans
- ✓ Water distribution systems
- ✓ Louvers
- ✓ Gear box and Drive shaft etc.,

Fills

Cooling tower fill is to position as much water surface area in touch with as much air as possible for the longest period of time viable. Fills allow the water to form thin flowing sheets to show as much water floor field as possible to the interacting flow.

- ✓ Fill material – PVC fill material
- ✓ PVC fills are high performance, heavy duty, law weight, excellent corrosion resistance.

Fan

Cooling towers may either use the evaporation of water to dispose of process heat and cool the working fluid to near the moist bulb air temperature or, within the case of closed circuit dry cooling towers, rely solely on air to chill the working fluid to close the dry bulb air temperature.

- ✓ Fan material - GRP, Aluminium, stainless steel etc.,

Water Distribution

This allows to hot water distribution above the fill material and flows over the fill then distribution to the cold water basin.

Drift Eliminators

Designed to get rid of water droplets from the discharged air and minimize loss of system water.

Drift eliminators intent the air and droplets to make unexpected alteration in course this causes the drops of water to be separated from the air and deposited again into the tower.

IV. PERFORMANCE APPROACH OF COOLING TOWER

Range:

It is the difference between the cold water in the basin and the warmer cooling water return.

Ex. Design is 95-85=10

Approach:

It is the difference between the cold cooling water temperature and the wet bulb temperature.

Ex.Typical 6 to 10 degrees

Cooling towers cannot cool water below the wet bulb temperature of the outside air.

Evaporation Rate:

$$E = 0.001X\ R\ X\ dT\ X\ EFC$$

Where:

R = Recirculation rate (3 gpm/ton)
dT = Temperature range
EFC = Evaporative Cooling Factor,~75%
Example: 1000 ton cooling load
E = 0.001x3000gpmx10Fx0.75
= 22.5 gpm = 32,400 gallons per day

Cycle of Concentration

The ratio between the impurity concentration in the recirculating water to the same impurity concentration in the make up water .

The ratio between makeup volume and the bleed volume.

V.CHANGING OF BLADE MATERIAL ALUMINIUM INSTEAD OF GRP

After iron, aluminium is the most widely used material in the world. The properties of aluminium include: good strength, malleability, corrosion resistance, low weight, high strength, and good thermal and electrical conductivity etc.,

VI. COMPARISION OF BLADE MATERIALS

Table 1.Comparision of blade materials

GRP	ALUMINIUM	STAINLESS STEEL
Low weight, less strength compared to aluminium	Low weight, high strength	high weight, high strength
Corrosion free but interior surfaces gets	Corrosion free	corrosion free

damaged		
Algae formation takes place	There is no algae formation	Algae formation is possible sometimes
Low evaporation loss	High evaporation loss	Medium Evaporation loss
External portray coating is needed	No need	External portray coating is needed
High maintenance cost	Low maintenance cost	High maintenance cost
Lifetime:5-7 years/blade	Lifetime:9-12 years/blade	Lifetime:6-8 years/blade

Specification of Blade Material
Material name : Aluminium (Al)
Blade length : 4.1m
Blade angle : 14.3^{o} instead of 13.7^{o}
Blade weight : 70kg

Changing of Blade Angle 14.3^{o} Instead of 13.7^{o}

When we have to change the blade angle (14.3^{o}) give better evaporation and to give better efficiency than the GRP blade angle (13.7^{o}).

VII. DESIGN AND ANALYSIS

In order to provide accurate results, the input boundary condition parameters are obtained from a real time cooling tower. The table below represents the values:

Table 2. Input parameters

Specification	Dimensions
No of blades	8 blades
Angle of blade	14.3^{0}
Material of blade	Aluminium

Right here ANSYS workbench is used for CFD analysis of cooling tower. For CFD evaluations following steps are performing. In this part step 1 to indicate cooling tower fan model is done by Solid Works, and then cooling tower models done by Solid works, which is transformed into STEP file and this step file are imported in ANSYS. In step 2 meshing of this cooling tower modeling is done. In meshing CFD mesh kind is selected and excellent meshing is completed with the aid of utilizing ten node tetrahedral factors. The rationale for picking out these details is that offers good meshing on curvature constituents. Right here the ANSYS is routinely select the aspect. In step 3 lots of domains is outlined. In these boundary conditions, the inlet hot water temperature is 39^{o}C, recooled outlet water temperature is 30^{o}C and the volume of circulating water circulated in cooling tower is $35m^{3}$/hr.

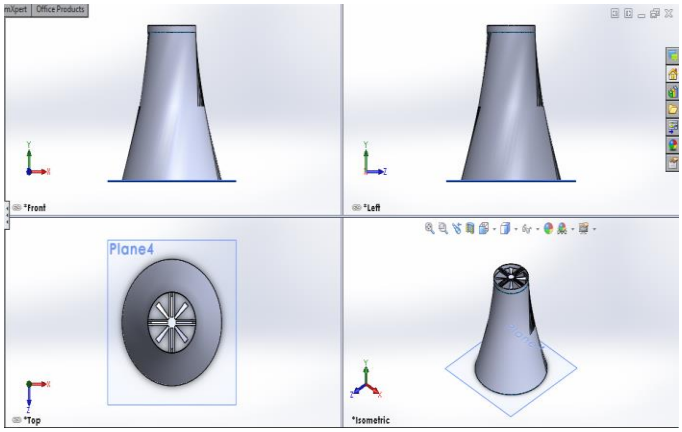

Fig .2 Modelling of cooling tower in solidworks

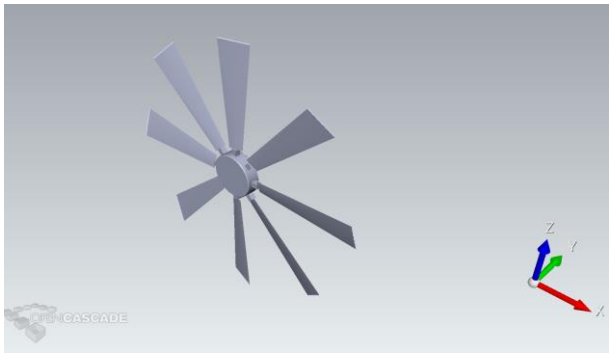
Fig .3 Modelling of cooling tower fan

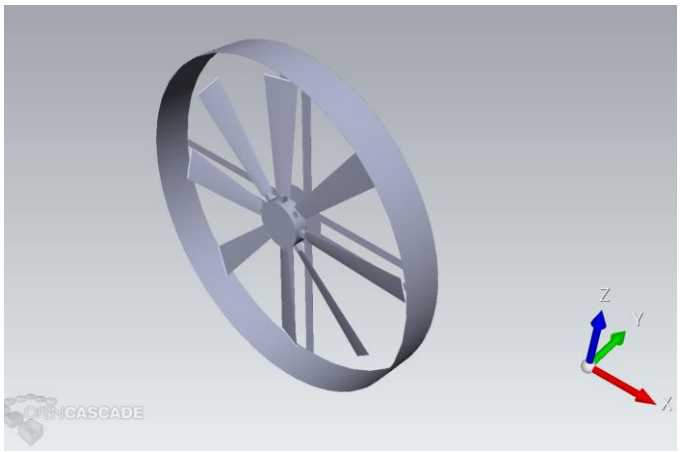
Fig .4 Modelling of cooling tower fan with outer casing

Boundary Condition

On Discrediting The Geometry, The Specific Boundary Conditions Should Be Assigned To The Surface Of The Elements, Which Decides The Behavior Of The Element To The Solver. The Following Working And Boundary Conditions Are To Evaluate The Performance Of 14.3^0 Blades. In The Fluent Solver, The Following Boundary And Solver Conditions Are Used:

Model: Cooling tower blade.

Material: Aluminium

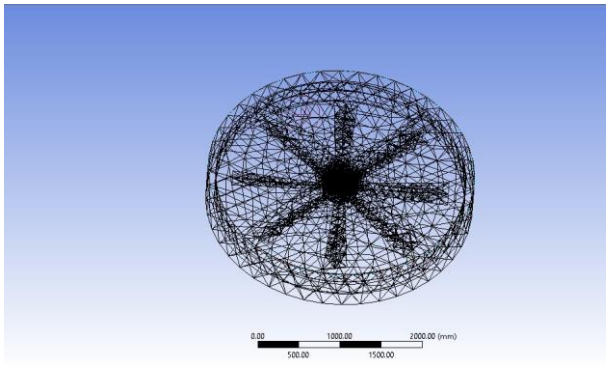

Fig .5 Details of meshing

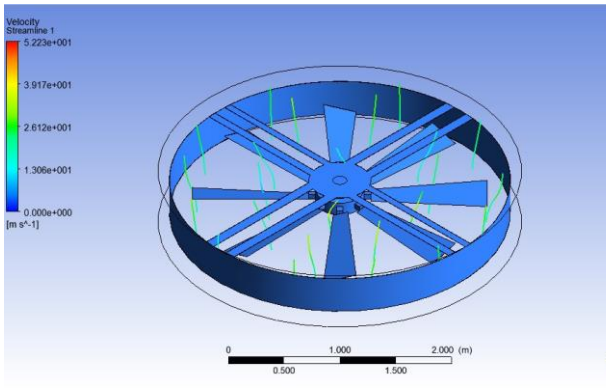

Fig .6 With boundary conditions

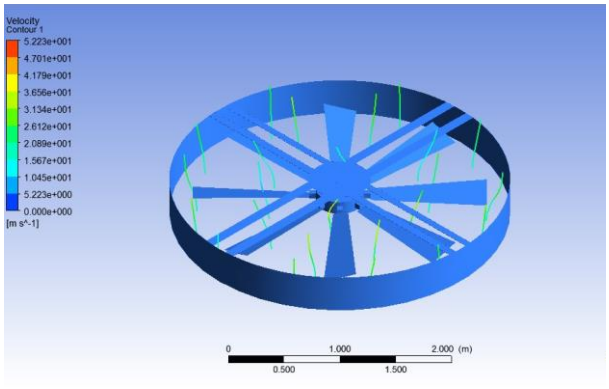

Fig .7 Velocity contour

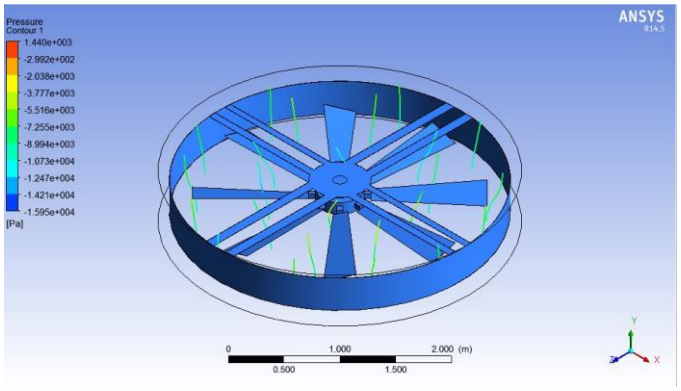

Fig .8 Pressure contour

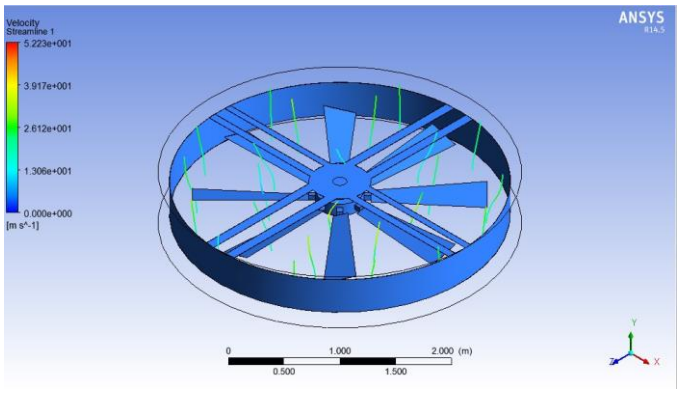

Fig .9 Velocity streamline

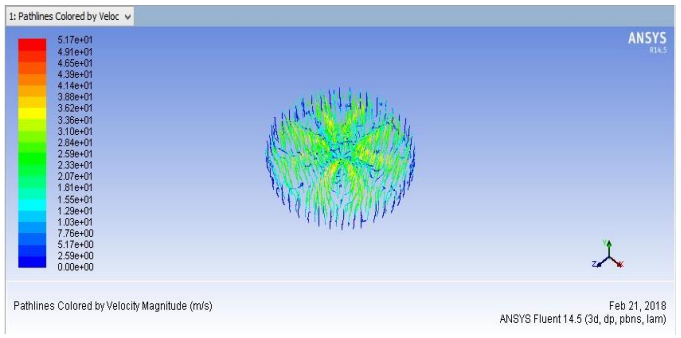

Fig .10 Pathlines coloured by velocity magnitude (m/s)

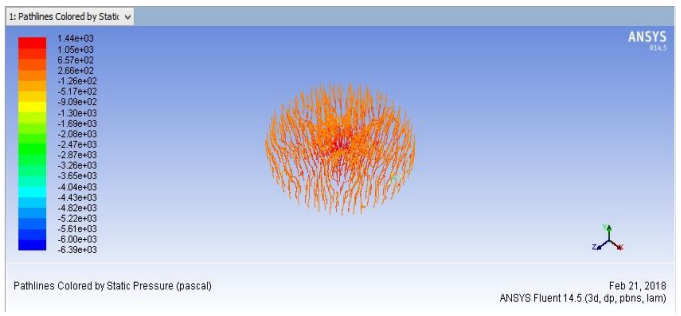

Fig .11 Pathlines coloured by static pressure (pascal)

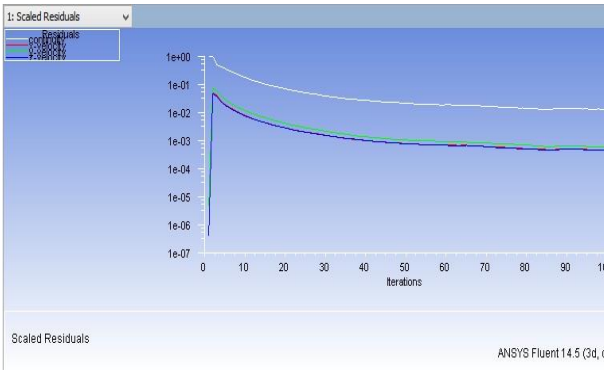

Fig .12 Scaled residuals

VIII. RESULT AND DISCUSSION

In this paper regards, efficiency improvement by changing blade angle (14.3^{o}) and blade material (aluminium) done by using analysis software's like CFD.

IX. CONCLUSION

In this paper a technique for assessment of Cooling Tower execution and distinctive writing overview from diverse research paper is introduced. Cooling Tower is utilized to decrease the temperature of hot liquid stream. It is mainly utilized as a part of ventilating plant, Chemical Plants and so forth. The plan of cooling tower is firmly identified with tower attributes and diverse kinds of misfortunes created in cooling tower. The main aim of this project to analysis changing of cooling tower fan material and cooling tower angle are done by using CFD.

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